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A Study of the Washing and Storage of Dirty Shell Eggs[1][2]

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SUMMARY AND CONCLUSIONS

The mechanical performance of 9 different types of egg-washing machines in 31 commercial plants in 7 Midwestern States was studied to determine the efficiency of the operation of these machines and how well the manufacturers' recommendations for their operation were observed. The number of cases of eggs washed per man-hour and the extent of machine breakage of eggs were recorded.

Bacteriological spot plates were used to determine the relative value of the machines and the sanitizing agents used in removing bacterial contamination from the surface of the shell. It was found that most of the plants were not following the manufacturer's instructions strictly and were not obtaining the maximum in results in the washing and sanitizing of dirty eggs.

Cases of eggs washed on various machines in different commercial plants were placed in storage, and at set intervals certain cases were removed for quality determination. The rate of quality decline in eggs

[1] This study was carried out under a cooperative agreement between the National Egg Products Association and the U. S. Department of Agriculture, and under the authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

[2] Acknowledgment is made of the cooperation of the many commercial firms in this study, and that of the manufacturers of egg-washing machines in supplying equipment and information necessary for the successful prosecution of the work; a complete list would be impractical to present in this publication. The assistance of A. William Jasper is also acknowledged.

[3] Resigned. Now director of research and development for a commercial firm.

placed in storage was found to differ for the various types of washing machines. Hand-washed eggs showed a higher rate of quality decline than did machine-washed eggs.

At the conclusion of the survey in the 31 commercial plants, 1 plant was selected for a more concentrated and controlled series of experiments. Four commercial egg-washing machines were installed in this plant and a comparison made of the washing of selected and randomized lots of dirty eggs. Cases of eggs washed by each machine were placed in storage, and at set intervals the eggs were removed from storage, candled for quality determination, and then broken out for the production of frozen eggs. Bacterial counts were made of the liquid from each half case (15 dozen) of eggs in each lot.

From the data obtained in these studies it is concluded that:

1. Dirty eggs should be washed, dried, and marketed or broken promptly, since storage of such eggs leads to economic loss.
2. Dirty eggs in the washed or unwashed state showed greater quality decline and loss during storage than did clean eggs.
3. Dirty eggs that had been washed (hereafter referred to as washed dirty eggs) showed greater quality decline during storage than did dirty eggs that had not been washed (unwashed dirty eggs).
4. The rate of quality decline in both washed and unwashed dirty eggs showed marked increase between the second and fourth month of storage—an indication that it is not practicable to store dirty eggs for more than 2 months.
5. Oil processing retarded the rate of quality decline in all eggs, and reduced the amount of loss. The bacterial counts in the oiled eggs were much lower than in those eggs stored as "naturals."
6. In commercial plants many of the egg-washing machines were not being operated in accordance with the manufacturer's directions. In many cases this accounted for the poor performance of the machines.
7. There was considerable variation in the number of cases of eggs washed per man-hour and in the cost of washing a case of eggs.
8. Some scrubbing or brushing action is necessary to remove the soil satisfactorily from dirty eggs, as water alone, or water used with a detergent, will not do so.
9. The use of hot water is advantageous and necessary in the washing of eggs, both from the washing standpoint and that of quality retention and prevention of loss in storage. (Eggs showing marked decline and loss had been washed in water that was cold or was not of the temperature recommended by the manufacturer of the machine.)
10. A short presoaking or spraying of eggs with warm water containing a detergent, offers an advantage in egg washing. This preliminary step softens the soil and facilitates its removal by the brushing or scrubbing action of the machine. The time and temperatures must be controlled to prevent contamination of the interior of the egg.
11. Washed eggs, even those washed under the best of controlled conditions, in accordance with the recommendations of the manufacturer of the machines, and with particular attention being paid to time, temperatures, and sanitizing agents used, showed a much higher loss and quality decline in storage than clean eggs.

INTRODUCTION

Dirty eggs constitute a serious marketing problem for the poultry industry in this country. It has been estimated that about 10 percent of all eggs produced require some degree of cleansing prior to marketing. It is recognized that the ideal solution to this problem would be to prevent eggs from becoming dirty initially, a problem that must be approached through an educational program coupled with a monetary incentive for producers. However, at present, the premise must be accepted that dirty eggs are being produced and that they must be handled in market channels. There is a great need for improvement in the methods of properly cleansing and sanitizing such eggs.

Soiled eggs must be handled separately from the clean eggs and this adds to the cost of handling all eggs. On the poultry farm, dirty eggs soil the clean eggs if they are placed together during the collection, cooling, and packaging, and thus serve to contaminate some of the clean eggs with spoilage micro-organisms. Dirty eggs are unsightly and must be removed from market lots of eggs not only for esthetic reasons but also from the standpoint of pricing and certain food handling requirements. The cost of segregation and cleaning must be borne by all eggs marketed, and in addition washed eggs generally command a lower price than naturally clean eggs.

It has been known for many years that most eggs are sterile at the time of laying (*2, 3, 14, 15*).[4] Haines and Moran (*7*), Stuart and McNally (*15*) and Wolk, McNally, and Spicknall (*18*) have pointed out that eggs may become grossly contaminated with bacteria if laid in a wet or filthy nest or allowed to become dirty. It was demonstrated that the rate of penetration of spoilage organisms is very rapid, especially at warm temperatures, and that a dirty egg must be rated as a potential spoilage hazard.

The washing of dirty eggs must be carried out in such a way as to render the shell clean and to prevent the surface contamination from penetrating the shell and the shell membrane. It is generally recognized that to accomplish this the water must be warmer than the egg in order that the warming of the contents will cause an expansion, thus forcing the contaminating material out of the pores to be carried away by the water.

During the annual season of high egg production a large number of shell eggs move into storage. The question has often been raised as to the most effective way to wash eggs and the practicability of moving washed dirty eggs into storage. Many different solutions to the problem have been proposed but comparatively few have found industrial use.

In 1914 Bushnell and Maurer (*3*) studied factors influencing the bacterial content of eggs and concluded that "washing reduces the keeping quality of an egg." Jenkins et al. (*8, 9*) demonstrated increased spoilage of washed eggs with increased storage time, and stated that "cleaning of dirty eggs whether by sponging, washing directly in water, or by treating with dilute sulphuric acid lowers their resistance to decay." Miller (*13*) stated that eggs could be washed and stored if the wash water were warmer than the egg and were maintained in a sterile condition, and if the eggs were dried before cooling, and if the dirt were removed before the interior of the egg became contaminated. However, he did not recommend the washing of eggs for storage as an industry practice.

Both Thompson (*16*) and Lorenz (*10*) concluded that washing eggs for storage was unsafe and that the only safe eggs to store were clean eggs, produced clean and unwashed. After a partial review of the literature

[4] Italic numbers in parentheses refer to Literature Cited, page 32.

Diehl (*4*) concluded in a report that, "until the problem is better solved, storing of washed eggs is unsafe, even though some lots of eggs may store satisfactorily." After some 10 years of experimentation Funk (*5*) concluded that thermostabilization offered the most effective method of preventing spoilage of washed dirty eggs in storage.

Even though most authorities agree that the washing of dirty eggs for storage is hazardous, the washing of dirty eggs is practiced throughout the egg-handling industry. Egg handlers, knowingly or otherwise, place many such eggs in storage. Several types of commercial egg-washing machines are on the market and are to be found in operation in hundreds of egg-handling plants throughout the Nation. The cleaning of approximately 10 percent of all eggs produced presents a major marketing problem.

A joint study on the washing and handling of dirty eggs was begun in the fall of 1948 by the National Egg Products Association and the Poultry Branch of the Production and Marketing Administration.[5] The objectives were (1) to determine how eggs were being washed commercially and the relative efficiency of results being obtained, (2) to determine which cleaning and sanitizing procedures were most effective in producing clean eggs and in insuring low bacterial counts, and (3) to compare the keeping qualities of washed shell eggs with those of unwashed eggs under current marketing and cold storage conditions.

The work was divided into two main phases: (1) A survey by questionnaire of commercial egg-handling establishments with respect to egg-washing equipment and operating conditions, and by personal inspection of several selected plants to determine the results being obtained, and (2) controlled experiments in one commercial plant to compare the results obtained from selected types of egg-cleaning equipment and procedures, both initially and after varying periods of storage of the washed eggs.

SURVEY OF COMMERCIAL PLANTS

Mail Questionnaire Survey of Egg-Washing Procedures and Facilities

Eight hundred questionnaires[6] on the handling of dirty eggs were sent directly to members of the National Egg Products Association and allied associations handling and processing eggs in the important egg-producing sections of the country in November 1948. As of March 31, 1949, 158 completed questionnaires had been received, or a return of approximately 20 percent. The results compiled from these questionnaires indicated that 33 plants were not washing dirty eggs or were opposed to washing; 25 were washing eggs by hand; 41 were cleaning eggs with abrasives; and 59 plants were using mechanical washers.

The information regarding the number of eggs washed, breakage, and cost of operation, was furnished by the individual companies and varied greatly from plant to plant. The breakage figures reported for machines using running or flowing water varied from 0 to 15 percent, for those using the soak tank principle 0.5 to 8 percent, and for those using abrasive methods 0 to 5 percent. Breakage from hand washing varied from 0.01 to 5 percent.

From the answers to certain questions it was concluded that considerable mechanical difficulty was being encountered in keeping the

[5] Cooperative agreement under the Agricultural Marketing Act of 1946 (RMA, Title II).

[6] U. S. D. A. Budget Bureau Form No. 40-48124.

machines in operation and that the recommendations and instructions of the manufacturers of the machines were not being followed with reference to water temperatures, detergents, and general operating procedures.

The data on the mechanical washers covered 137 machines located in 25 States. Most of the washers were in Iowa, Minnesota, Nebraska, Illinois, Kansas, Missouri, and New Jersey. Of the 137 machines listed, 120 were of 6 commercial types. The questionnaire data were composited according to type of machine with respect to the eggs washed and the breakage as follows:

Machine No. 1.[7] —The 26 machines of this type showed outputs of washed eggs varying from 3 to 13.5 cases of eggs per man-hour, the average being 7.1 cases. Breakage varied from 0.5 to 8 percent; average, 1.8 percent.

Machine No. 2.—Twenty-nine machines of this type were in use with outputs varying from 2 to 5 cases of eggs per man-hour; average, 3.4 cases. Breakage varied from 0 to 5 percent; average, 1.2 percent.

Machine No. 3.—This type was represented by 8 machines, each of which washed 3 to 4 cases of eggs per man-hour. The breakage varied from 0.1 to 1 percent; average, 0.44 percent.

Machine No. 4.—This machine was being used in 29 plants and the output varied from 2 to 5 cases per man-hour; average, 4.1. Breakage varied from 0.13 to 15 percent; average, 4 percent.

Machine No. 5.—This type was reported from only 5 plants. The output varied from 2 to 20 cases per man-hour; average, 8.9. Breakage was reported as 1 to 5 percent.

Machine No. 6.—This was found in 23 plants. The cases of dirty eggs washed per man-hour varied from 3 to 6; average, 4. Breakage averaged about 1 percent.

Survey of Egg-Washing Procedures and Equipment in Commercial Plants

As it was not possible to observe the washing procedures in all egg-handling plants, a selected list of plants was chosen as representative of the industry. Twenty-nine plants in seven North Central States were selected for the work. These plants were chosen on the basis of location, type of cleaning machines used, techniques employed, and willingness of management to participate. They were in Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, and Wisconsin. It is believed that they were representative of the processors and handlers in the industry.

In these 29 plants, 9 types of machines were in commercial use for the washing of dirty eggs, in addition to hand-washing. Data were recorded on 31 egg-washing machines in the 29 plants, certain makes of machines being used in several plants and others being used in only 1 plant.

In general, the washing machines employed one of two principles: In some the eggs were washed while they were submerged in water; in others the eggs were washed with water being conveyed to them in various ways. Most of the machines employed some type of scrubbing or abrasive action to assist in the removal of the soil.

Some machines were so designed that workers had to remove the clean eggs with the same hand they used to put the dirty eggs in the machine, thus transferring filth from the dirty to the cleaned eggs.

Detergents, sanitizers, and controlled water temperatures were employed in certain machines and used according to the directions and recommendations of the manufacturers of the machines. Some manufacturers advocated short soak-periods to loosen the soil. Certain machines used hot water whereas others used tap water. One of the ob-

[7] Because it is the policy of both the N. E. P. A. Research Laboratory and the U. S. Department of Agriculture to avoid listing commercial products by name, the egg-washing machines are referred to only by code numbers, the same reference numbers being used throughout this circular.

jectives of the plant survey was to determine the extent to which the manufacturers' instructions and recommendations were being followed in the routine washing of dirty eggs.

Records were made in each plant describing in detail the operation of the egg-washing machines in use in that plant. Each type of machine was assigned a number and all information gathered from the various plants using this type of machine was utilized in arriving at an estimate of its performance. Whenever possible observations were made of several trials on each machine in each plant to determine the variability of results.

Machine No. 1 was used in eight plants; Machine No. 2 in four plants; Machine No. 3 and No. 4 in five plants; machines No. 5 and No. 6 in three plants; and machines No. 7, No. 8, and No. 9 in one plant each. The hand washing of dirty eggs was studied in one plant. The eggs were washed for immediate breaking by placing them in wire baskets and soaking them in 80° F. water containing a detergent. They were then spray-washed by means of a hose with water having a temperature of 76° to 84°. When necessary, a metal sponge was used to remove the adhering soil. The washed eggs were rinsed by dipping them several times in water having a temperature of 56° to 69° F. and containing a sanitizing agent.

OBSERVATIONS OF MACHINE-WASHING AND HAND-WASHING OF EGGS

In each plant a study was made of the operation of egg-washing machines to determine (1) the type of dirty eggs being washed, (2) the relative efficiency of cleaning, (3) the number of cases of dirty eggs washed per man-hour of labor, and (4) the observance of manufacturers' recommendations for operating the machine. In determining the cleaning efficiency, the eggs being processed and the eggs coming from the machines were compared with photographs (figs. 1 and 2) of dirty unwashed eggs, eggs that had been washed but were not clean and, therefore, had to be rewashed, eggs that had been washed satisfactorily, and naturally clean eggs.

The following data were obtained on the various machines:

Machine No. 1 was operated in eight plants—six egg-breaking plants, one egg-breaking plant and packing plant, and one packing plant. The machines were operated by one person in six plants, and by two persons in the other plants. The manufacturer's recommendations were followed rather closely in six plants; they were not being followed in two plants.

Light to medium dirties were washed in one plant, medium to heavy dirties were washed in three plants, and heavy dirties were washed in the other four plants. The eggs in all eight plants were handled in a sanitary manner after being washed.

The eggs were well cleansed in all but one plant; in that plant, the cleansed eggs were considered as fair or classed for "rerun" through the machine. The heavy dirties were washed by one operator, and the manufacturer's recommendations were followed except for the type of detergent and germicide used.

The number of cases of dirty eggs washed per man-hour in the No. 1 machine ranged from 4 to 12.5, the average being 6.6 for 5 of the 8 trials on which this information was noted. One operator was used in each of 6 plants. In the 2 plants where the machines were operated by 2 persons, 5 and 6.9 cases of dirty eggs were washed per man-hour. Heavy dirties were washed by the machine that washed 12.5 cases of dirty eggs per man-

FIGURE 1.—*A*, Dirty eggs before washing. *B*, Improperly washed dirty eggs that must be run through the washer a second time.

hour, and the eggs were well cleansed. No information was recorded which indicates any apparent reason for the large difference in the number of cases of dirty eggs washed per man-hour in different plants, with the same type of machine. Breakage with the No. 1 machine was consistently less than 1 percent.

Machine No. 2 was operated in four plants—two egg-breaking plants, one egg-breaking and packing plant, and one packing plant.

The machines were operated by two persons in each of three plants and by one person in the other plant. The manufacturer's recommendations were followed rather closely in three plants.

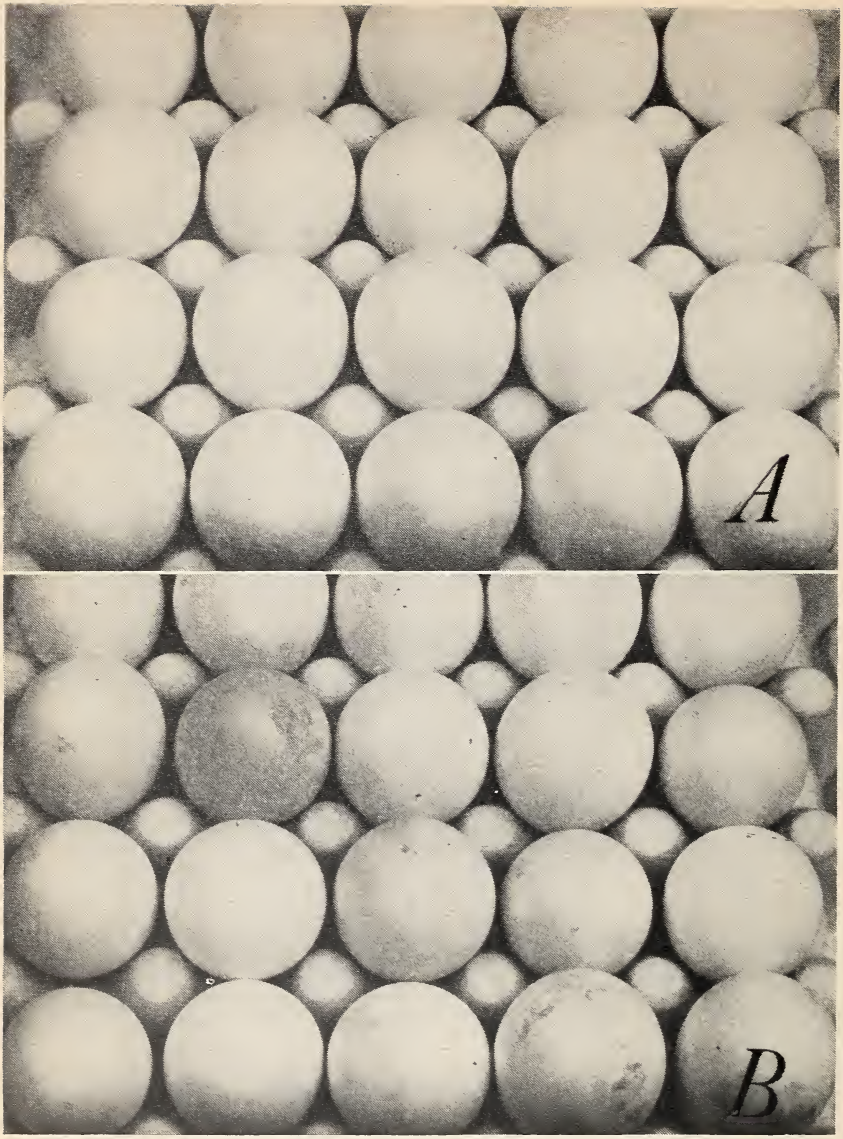

FIGURE 2.—*A*, Naturally clean eggs. *B*, Properly washed dirty eggs. The stains on the shells of such eggs cannot be removed by washing.

Medium to heavy dirties were washed in three plants and heavy "caked" dirties were washed in the other plant. The eggs in three plants were handled in a sanitary manner after being washed. One plant employed a single operator who removed clean eggs from the machine as well as placed dirty eggs in the machine without washing his hands.

The eggs were well cleansed in all but one plant. In this plant the cleansed eggs were classed as "reruns" or dirties. This was in the plant where heavy "caked" dirties were washed. The manufacturer's recommendations were followed and two machine operators were used but the machine was not capable of washing eggs that tended to be mud balls.

The number of cases of dirty eggs washed per man-hour in the No. 2 machines ranged from 3.2 to 8, the average for the 4 trials being 5.7. Breakage in the No. 2 machine was less than 1 percent for all 4 trials.

Machine No. 3 was operated in five packing plants. The machines were operated by one person in each plant, and the manufacturer's recommendations were followed rather closely in all plants.

Only light to medium dirties were washed in this machine. The eggs were all well cleansed, but they were not handled in a sanitary manner after being washed in four of the five plants. It was very difficult to handle eggs washed by this machine in a sanitary manner without employing two operators.

The number of cases of dirty eggs washed per man-hour with this machine ranged from 3.7 to 4.6. Breakage was less than 1 percent in all 5 plants; however, it was noted in 4 plants that the machine did break checks and heavy dirties.

Machine No. 4 was found in five plants—four egg-breaking plants and one egg-packing plant. Two trials were run in one of the breaking plants and one trial in each of the others— a total of six trials. The machines were operated by one person during five trials and by three persons in the other trial. The machine operated by 3 persons was the largest. The manufacturer's recommendations were followed closely during only one trial run.

Medium to heavy dirties were washed in four trials, light to medium dirties in one trial, and heavy dirties in one trial.

The eggs were well cleansed in three trials, fairly well cleansed in two trials, and poorly cleansed in one trial. The eggs that were only fairly well cleansed were medium to heavy dirties in one trial and heavy dirties in the other trial. The trial in which the eggs were poorly cleansed was made on the large machine operated by 3 persons. The manufacturer's recommendations were not followed during the three trials in which the eggs were not well cleansed.

The number of cases of dirty eggs washed per man-hour with the No. 4 machines, ranged from 2 to 4.5, the average for the 6 trials being 3.6. During one trial, however, one of the small machines was operating at about 85 percent capacity because of a mechanical defect. If this trial is omitted, the number of cases of dirty eggs washed per man-hour varied from 2.5 to 4.5, or an average of 3.9 for five trials. The large machine gave no higher output per man-hour than the small machine.

Breakage with the No. 4 machine was less than 1 percent in five trials but reached 2.5 percent in the other trial.

Machine No. 5 was operated in 3 egg-breaking plants. One machine operator was used in each plant, and the manufacturer's recommendations were followed rather closely in all three plants. The eggs were not well cleansed in any of the plants.

Medium to heavy dirties were washed in one plant and heavy dirties were washed in the other two plants. All eggs were handled in a sanitary manner after being washed.

The number of cases of dirty eggs washed per man-hour with this machine ranged from 5 to 10.8, or an average of 7.9 for the 3 trials. Heavy dirty eggs were washed by the machines that turned out 5 and 10.8 cases per man-hour, and the eggs washed at the rate of 10.8 cases per man-hour were cleaned somewhat better than any of the other eggs. Breakage with the No. 5 machine was consistently less than 1 percent.

Machine No. 6 was operated in three egg-packing plants; four trials

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were made in one of the plants, and one in each of the others—a total of six trials. Three of the four trials in one plant were conducted on an experimental basis. The machines were operated by one person at five of the trials and by two persons during the other trial. The manufacturer's recommendations were followed rather closely for all six trials, although difficulty was encountered in maintaining the proper water temperature during three of the four trials conducted in one plant.

Light dirties were washed in three trials, light to medium dirties in two trials, and light to heavy dirties in one trial. All eggs were handled in a sanitary manner after being washed.

The eggs were well cleansed in five of the six trials. In the other trial, the eggs were only fairly well cleansed, even though proper water temperature was maintained for this particular trial.

The number of cases of dirty eggs washed per man-hour with this machine ranged from 2.5 to 3.3, the average for three of the commercial trials on which this information was noted being 2.9.

Breakage with this machine was less than 1 percent during the three trials on which this information was noted; however, it was reported from two other trials that the machine did break checks.

Machine No. 7 was used for only one trial in an egg-packing plant. It was operated by one person. The manufacturer's recommendations were not followed in that the temperature of the wash water was not maintained at the recommended level.

Light to medium dirties were washed by this machine. The eggs were all well cleansed and were handled in a sanitary manner after being washed.

In this trial, 8.8 cases of dirty eggs were washed per man-hour with this machine. Breakage was negligible; however, it was noted that the machine did break checks.

Machine No. 8 was a company-made machine and was operated in an egg-breaking plant on an experimental basis. Five machine operators were used—two fed eggs to the machine, two removed cleansed eggs, and one supplied eggs. The recommendations for operation were followed rather closely.

Medium to heavy dirties were washed by this machine. All the eggs were well cleansed and were handled in a sanitary manner after being washed. Timed on an experimental basis only, the trial showed that 9 cases of dirty eggs were washed per man-hour by this machine. No data were recorded on breakage.

Machine No. 9 was operated on an experimental basis in an egg-breaking plant. One machine operator completed four separate trials. Warm water was used, as recommended, as the sole washing agent in one trial. For two other trials, warm water was used containing a different washing compound for each trial, and for one trial warm water containing a washing compound different from the other two was used and the washing was followed by a germicidal rinse. It was not possible to maintain the water temperature as high as recommended by the manufacturer since during continuous operation of the machine the water temperature dropped.

Heavy dirties were washed during all four trials. The eggs were not handled in a sanitary manner, as according to the usual method of operation the one operator who feeds the dirty eggs into the machine must remove the clean eggs for packing purposes.

The eggs were well cleansed in three trials, but were only fairly well cleansed during the trial in which warm water alone was used as the wash-

ing agent. It was observed that considerable manipulation by the operator was necessary to effectively cleanse the surface of abnormally large or of small eggs.

On the average, only 0.3 of a case of heavy dirty eggs was washed per man-hour in this machine. No eggs were broken by the machine during the four trials.

Hand washing of eggs was carried out on a commercial basis in one egg-breaking plant and data were recorded. The dirty eggs were soaked for a short time in warm water containing a detergent. The eggs were then spray-washed with water at a temperature of approximately 80° F. and were then dipped several times into a germicidal rinse. Three persons worked together during the hand-washing operation. Any dirt that was not removed by this treatment was removed by hand rubbing.

Light dirties to "mud balls" were hand-washed. The eggs were well cleansed and were handled in a sanitary manner after being washed.

Approximately two cases of light to very heavy dirty eggs were hand-washed per man-hour of labor. There was 1.5 to 2.0 percent breakage. This breakage figure is higher than the average for any of the washing machines studied.

A summary of the number of eggs washed per man-hour on the machines discussed is given in table 1.

BACTERIOLOGICAL RESULTS

In order to determine the relative efficiency of the removal of bacteria from the shell during the washing of dirty eggs the "spot-plate" technique of Gunderson and Gunderson (*6*) was used. This involved the rolling of a shell egg across the surface of a plate of a prepared bacterial culture medium and counting the number of bacterial colonies that developed during incubation. The area of the surface of the egg which was in contact with the medium was calculated to be 16 sq. cm. and it was estimated to be the same in each case, because each time the egg was rolled from one border of the plate to the other. Accordingly, the number of bacterial colonies counted on the plates was reported as representing the number of bacteria on the unit area of the eggshell that contacted the culture medium and not for the entire shell surface. As a check of air contamination spot plates were exposed to the atmosphere for a time comparable with that required to make the usual spot plate tests.

Sixteen spot plates were made from eggs in each trial run at definite time periods during the morning and afternoon. Samples were taken from 12 washed eggs and 4 from clean eggs that had not been washed. All spot plates were poured with Tryptone Glucose Extract Agar (*1*) and incubated for 48 hours at 37° C. (98.6° F.).

The air contamination of the spot plates during manipulation was found to be very low. From a total of 160 spot plate controls only 2 could be classed as having excessive air contamination. One control plate showed 14 bacteria and the other 48; the latter was in a plant where the washing machine was operated in a live poultry receiving area.

The results of the bacterial counts of the shell surfaces of washed eggs are shown in table 2.

Of the eggs washed by machine No. 1, 83 percent had spot-plate counts ranging from 0 to 50, 10.6 percent from 51 to 100, and only 6.4 percent had plates with colonies too numerous to count.

It will be recalled that the manufacturer's recommendations were followed rather closely in 6 of the 8 plants in which the No. 1 machines

TABLE 1.—*Number of eggs washed per man-hour by 9 machines and by hand, in 31 Midwestern egg-handling plants, 1949*

Machine	Trials	Cases of eggs washed per man-hour		
		Low	High	Average
	Number	*Number*	*Number*	*Number*
No. 1	5	4.0	12.5	6.6
No. 2	4	3.2	8.0	5.7
No. 3	5	3.7	4.6	4.3
No. 4	6	2.0	4.5	3.6
No. 5	3	5.0	10.8	7.9
No. 6	3	2.5	3.3	2.9
No. 7	1	8.8	8.8	8.8
No. 8	1	9.0	9.0	9.0
No. 9	4	.2	.4	.3
Hand washed	1			2.0

TABLE 2.—*Bacterial and mold counts* [1] *from spot plates taken from the surfaces of eggs washed by 9 commercial egg-washing machines and by hand in 31 Midwestern egg-handling plants, 1949*

Egg-washing machine	Washing trials	Bacterial and mold counts in range		
		0–50	51–100	TNTC[2]
	Number	*Percent*	*Percent*	*Percent*
No. 1	8	83.0	10.6	6.4
No. 2	4	39.6	16.7	43.7
No. 3	5	33.3	3.3	63.4
No. 4	6	19.1	22.1	58.8
No. 5	3	52.8	27.8	19.4
No. 6	6	33.3	0.0	66.6
No. 7	1	0.0	0.0	100.0
No. 8	1	100.0	0.0	0.0
No. 9	5	43.3	10.0	46.6
Hand washed	1	66.6	16.7	16.7

[1] "Spot plates" are reported in numbers of colonies per 16 sq. cm.
[2] Bacterial colonies on spot plates "too numerous to count."

were used. The eggs were handled in a sanitary manner after being washed in all 8 plants.

Of the eggs washed by the No. 2 machines, 39.6 percent of the spot plates had counts ranging from 0 to 50, 16.7 percent from 51 to 100, and 43.7 percent had colonies too numerous to count. The principal reason for the high counts on eggs washed by the No. 2 machines was that insufficient quantities of detergents were used for washing. In addition, incompatible and improper concentrations of detergents and sanitizing agents were used in one plant. This was in a plant where 9 out of 12 spot plates had colonies too numerous to count. From one of the older models of the No. 2 machine the cleansed eggs were removed by dirty and contaminated hands when only one operator was employed. In this plant all 12 spot plates had colonies too numerous to count.

Eggs cleansed by the No. 3 machines were washed on a comparatively equal basis in 5 plants. Of the eggs washed by these machines, 33.3 percent of the spot plates had counts ranging from 0 to 50, only 3.3 percent had counts from 51 to 100, whereas 63.4 percent had colonies too

numerous to count. Twelve spot plates from eggs washed by one machine had counts ranging from 0 to 6, with an average of 1.3. Eleven spot plates out of 12 from eggs washed by one machine, and all 12 spot plates from eggs washed by each of two other machines, had colonies too numerous to count. It was evident that the unsanitary handling of the cleansed eggs was responsible for the great difference between the excellent results obtained with one machine and the relatively poor results obtained with the other four machines. Eggs washed by the machine from which excellent results were obtained were handled in a sanitary manner after being washed, whereas this was not true for the eggs washed by the other four machines.

Of the eggs washed by the No. 4 machines, 19.1 percent of the samples had counts ranging from 0 to 50, 22.1 percent from 51 to 100, and 58.8 percent had colonies too numerous to count. Six trials were made in five plants and in only one plant were the manufacturer's instructions followed and this probably accounts for the high bacterial counts. In 5 of the trials from 3 to 12 samples in each trial showed colonies too numerous to count. The temperature (125° to 130° F.) of the wash water recommended by the manufacturers was not reached in any of the plants studied. The temperature of the water in actual use varied from 90° to 115° F. and it was evident that the water was not hot enough to properly cleanse and sanitize the shell surfaces of the eggs. In only 3 trials were the eggs judged to be well cleaned.

Of the eggs washed by the No. 5 machines, 52.8 percent of the spot plates had counts ranging from 0 to 50, 27.8 percent from 51 to 100, and 19.4 percent had colonies too numerous to count. One-half of the spot plates from eggs washed in one plant had colonies too numerous to count, the eggs having been heavy dirties which were not well cleansed. It appeared that some abrasive action was needed to more effectively remove the soil from the surface of eggs washed by the No. 5 machines.

One-third of the spot plates made from eggs washed by the No. 6 machines had counts which ranged from 0 to 50. These plates were all from two trials. Two-thirds of the spot plates made from eggs in the other four trials had colonies too numerous to count.

The high spot plate counts on eggs washed by the No. 6 machines indicate that washing and sanitizing effects with water at the temperatures used were unsatisfactory. It was believed that more satisfactory results could be obtained if a detergent-sanitizing compound were added to the wash water. This was done during the two trials which resulted in low bacterial counts.

All 12 spot plates from the eggs in the one trial washed by the No. 7 machine had colonies too numerous to count. It will be recalled that the recommended wash water temperature was not maintained during the only trial made with this machine. It is believed that the efficiency of this machine would be improved if the manufacturer were to recommend definite quantities of a detergent or detergent-sanitizing agent for use in the presoaking process, and that the washing be followed by a germicidal rinse.

Spot plate results from eggs washed by the No. 8 machine showed all 12 plates with less than 50 colonies. This was a company-made machine operated on an experimental basis.

Five sets of 12 spot plates were made from eggs washed by machine No. 9. All of these were taken in the same plant but at different times. The spot plate counts showed 43.3 percent to be in the range of 0 to 50, 10 percent from 51 to 100, and 46.6 percent to have colonies too numerous

to count. In 4 of the trials a sanitizing agent was used. In the fifth trial only water at a temperature of 132° F. was used and this resulted in all 12 of the samples having colonies too numerous to count. In the operation of this machine the person who fed the dirty eggs into the machine also removed the cleaned eggs and this handling of dirty eggs as well as clean ones was probably responsible for some of the high counts. Also, the temperature of the water recommended by the manufacturers was not maintained during the trials.

Twelve spot plates were made from eggs washed by hand on a commercial basis. Two-thirds of these spot plates had counts which ranged from 0 to 50, 16.7 percent had counts from 51 to 100, and 16.7 percent had colonies too numerous to count.

STORAGE STUDY

As a preliminary step to a more comprehensive study, a limited number of cases of eggs was followed through 7 months of storage.

Between May 25 and August 18, 1949, 35 cases of washed dirty eggs 5 cases of unwashed dirty eggs, and 5 cases of unwashed clean eggs were placed in commercial storage, in 9 lots of 5 cases each. Each washed lot represented a different washing treatment and was processed in a different egg-handling plant. The lots were as follows:

5 cases—clean, unwashed
5 cases—soiled, unwashed
5 cases—hand washed
25 cases—each lot of 5 cases washed by a different mechanical egg-washing machine
5 cases—washed by one of the machines and oil-processed

The cases of eggs were shipped to Chicago and placed in cold storage. All eggs were graded by the same egg grader of the U. S. Department of Agriculture, before being stored and after 3, 5, and 7 months of storage.

In order to evaluate better the quality changes during storage, grade points were assigned to each quality grade in accordance with the procedure outlined in Michigan Agricultural Experiment Station Special Bulletin 361 (*12*). Four points were assigned for "A" quality, 3 points for "B" quality, 2 points for "C" quality, 1 point for "Checks" and 0 for "Leakers and Loss." The appearance of the shell was disregarded in the case of "Stains and Dirties" in identifying the interior quality changes. It is apparent that the higher the number of quality grade points, the better the candling quality of the eggs. At the end of 7 months' storage, the eggs were graded and broken, and the total losses were determined. The results of this study are given in table 3.

It is interesting to note that although the eggs were assembled and washed in different States and during different months the average initial grade points of the various lots showed a maximum variation of only 61.4 points. The initial quality of all eggs averaged 343.9 grade points.

It will be noted that the percentage point decline in washed eggs ranged from 50.1 for eggs washed by machine No. 6 to 24.1 for hand-washed eggs. The unwashed soiled eggs showed a point decline of 32.0 percent whereas unwashed clean eggs showed 20.8 percent.

After 7 months of storage all eggs were candled to determine the interior quality and the loss. The eggs which were judged to be edible by candling were then broken out and the amount of loss due to appearance and odor was recorded. The smallest amount of loss, 2.2 percent, was found in the eggs washed by machine No. 3. The highest loss was 41.0 percent in eggs washed by the No. 5 machine; the second highest loss was in eggs which had been washed by hand. Eggs washed by machines No. 5 and No. 6 showed marked loss after storage. Eggs from

TABLE 3.—*Quality changes and losses in eggs washed by different methods and stored for 3, 5, and 7 months*

Treatment	Quality grade points				Decline in quality during storage		Percentage of loss during storage period		
	Initial grading	After 2 months	After 5 months	After 7 months	Total point decline after 7 months	Point decline as a percentage of initial grading	Candling[1]	Breaking-out	Total
	Points	*Points*	*Points*	*Points*	*Points*	*Percent*	*Percent*	*Percent*	*Percent*
Clean, unwashed	351.5	318.7	295.3	278.2	73.3	20.8	2.8	1.4	4.2
Soiled, unwashed	314.4	285.1	243.4	213.7	100.7	32.0	16.7	10.6	27.3
Hand washed	375.8	350.5	318.9	285.0	90.8	24.1	6.0	34.5	40.5
Machine No. 1	352.0	312.5	280.0	237.3	114.7	32.5	8.0	17.7	25.7
Machine No. 1 (Oil Process)	346.2	314.7	291.9	262.8	83.4	24.0	7.6	3.6	11.2
Machine No. 3	356.5	312.0	289.0	269.0	87.5	24.5	1.9	0.3	2.2
Machine No. 4	338.5	297.5	267.8	214.2	124.3	36.7	17.7	7.2	24.9
Machine No. 5	320.9	276.9	251.3	183.2	137.7	42.9	26.5	14.5	41.0
Machine No. 6	339.3	284.2	239.5	169.0	170.3	50.1	27.7	9.9	37.6

[1] Includes leakers, rots, stuck yolks, etc., classified as losses by candler.

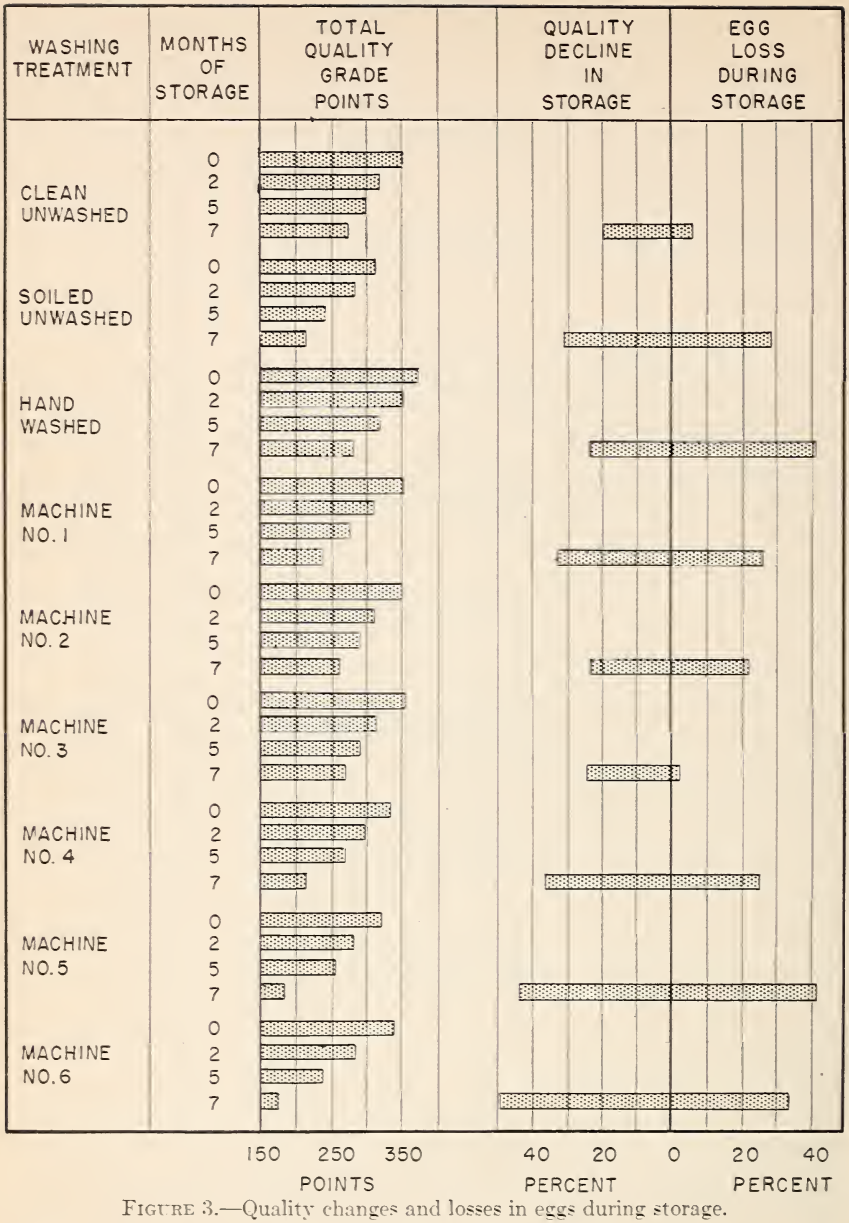


FIGURE 3.—Quality changes and losses in eggs during storage.

these machines also showed the greatest points of decline in quality. It is of interest that hand-washed eggs showed a low quality-point decline but showed a very high broken-out loss.

Quality changes and losses during storage are presented in figure 3.

COST DATA

During the study of the performance of some commercial egg-washing machines, considerable information on cost items was obtained. In-

quiry was made of the plant management as to the initial cost of the washer, the cost of repairs, direct labor costs, and the indirect costs for water, electricity, and chemicals. Some of the information reported in table 4 was obtained through observation and calculation, but most of it was furnished by the company operating the washers. The costs of such items as water, electricity, and chemical could not be determined directly and were, therefore, based upon the company estimates. The costs of labor and other items varied according to geographic location, and this no doubt accounts for a considerable variation in the cost of these items as reported for the same type of machine in different plants. Although limited in coverage, it is believed that the following data on the average figures reported for the various machines will be of interest.

Information on machine No. 1 was obtained from 8 plants. The dirty eggs washed in these plants varied from 4 to 30 percent of the total volume. The initial cost of the machines was essentially the same in all plants and all had been purchased within a 2-year period. Of the 8 machines, 5 had required no repair. The repair on the 3 machines ranged from $65 to $100 for a 2-year period. The number of cases washed per man-hour varied from 4.5 to 12.5, with an average of 7.5. The labor cost was, therefore, quite variable, ranging from a low of 7.5 to a high of 15 cents per case, with an average for the 8 machines of 11.2 cents per case. The indirect costs were between 3 and 7 cents per case. The average total cost of washing eggs was 15.8 cents per case.

Information on machine No. 2 was obtained in four plants. The initial cost on two of the machines was much higher than on the other two as they were larger and later models. Two of the machines were 2 years old and cost of repairs had been $40 and $140, respectively. The other machines had been in service less than a year and had no repair costs. The number of cases of eggs washed per man-hour ranged from 3.2 to 8 and the labor costs ranged from 9.5 to 23 cents per case, with an average of 17.5 cents. The indirect costs were from 1.1 to 3.0 cents per case. The average total cost of washing eggs was 19.2 cents per case.

Data were obtained on machine No. 3 from five plants. The initial cost varied greatly, being twice that in some plants compared with others. This variation in cost was probably due to the development of successive models of the machine. These machines were only 1 year old and the only repair charge was $8 on one machine. The number of cases of eggs washed per man-hour ranged from 3 to 8.5, whereas the labor cost ranged from 10 to 25 cents per case, with an average of 21.7 cents. The indirect costs ranged from 1 to 10 cents per case. The average total cost of washing eggs was 21.7 cents per case.

Operational data were obtained on Machine No. 4 in five plants. The initial cost of four of the machines was essentially the same; the other machine was larger and cost nearly four times as much as the others. Repair expenses on one of the small machines was $20 at the end of 1 year and $10 on another machine 2 years old, whereas the repair on the large machine over a 2-year period was $65. The number of cases of eggs washed per man-hour varied from four to five cases. The labor cost on the small machines ranged from 15 to 21 cents per case, with an average of 17.5 cents. The indirect costs were 3.0 to 6.0 cents per case, and the average total cost was 21.9 cents for washing a case of eggs on the small machines.

The large machine which was operated by three persons washed five cases of dirty eggs per man-hour, averaging 18 cents for labor cost per case and 1.5 cents for indirect costs. The average total cost of washing eggs with this machine was 19.5 cents per case.

Data on machine No. 5 were obtained from three plants. One of the machines had been in use 6 years and the repair cost had been less than $5. The other two machines were 4 years old and there had been no bill for repairs. The number of eggs washed ranged from 8.0 to 10.7 cases per man-hour. This was the highest of any of the machines under study but it should be noted that the cleansing of all of the eggs was not equal to that of the other machines.

The direct labor costs averaged 8.5 cents per case of eggs washed and the indirect costs averaged 5.8 cents per case. The average total cost of washing eggs was 14.3 cents per case.

Machine No. 6 was reported from only one plant. The average number of eggs washed per man-hour was 2.5 cases. The breakage in this machine was high, running 5 percent as compared with less than 1 percent for most of the other types of machines. The direct labor cost averaged 30 cents per case, the indirect costs 4 cents per case, making a total cost of 34 cents per case to wash eggs with this machine.

Information on the washing of dirty eggs by hand was obtained from one plant. The average number of cases washed per man-hour was 0.9. The breakage of eggs was 4 percent under this system. The labor cost averaged 24.2 cents per case and the indirect costs 1.2 cents. The total average cost of washing a case of eggs by hand was 25.3 cents.

Cost data on the various types of washing equipment is given in table 4.

CONTROLLED COMMERCIAL WASHING, STORAGE, AND BREAKING OF EGGS

The preliminary work carried out in the survey of commercial plants pointed to the desirability of obtaining comparative data on eggs washed by different machines under conditions that would eliminate variations which might be due to differences in raw material, location, plant operations, techniques, and efficiency of personnel. The cooperation of a large egg-processing firm was obtained and the work under controlled conditions was carried out in one plant by the same group of workers.

Four machines were selected for the study on the basis of general performance, observed during the earlier phase of the work, and the record of quality deterioration and loss. The machines listed for this work are the same type of machine and bear the same numbers as those observed earlier. Each of the machines was installed by the manufacturer and was operated in accordance with his recommendations and instructions, but his representative was not present during the tests.

The soiled eggs used in the study were classified as "dirties to heavy dirties." Each day for a period of 6 days, beginning April 27, 1950, the company put aside 30 cases of dirty eggs. The eggs in each lot of 30 cases were then "randomized" in such a manner that the same type of dirty eggs would go to each washing machine.

After allowing 2 cases out of each 30 for replacement purposes, the remaining 28 were divided into 4 lots of 7 cases each. Each lot of 7 cases of "randomized" dirty eggs was then washed in one of the four machines. After the eggs were washed and dried they were put in cases with new flats and fillers, and were stored at 45° to 50° F. so that all eggs would be of a uniform temperature at the time of grading.

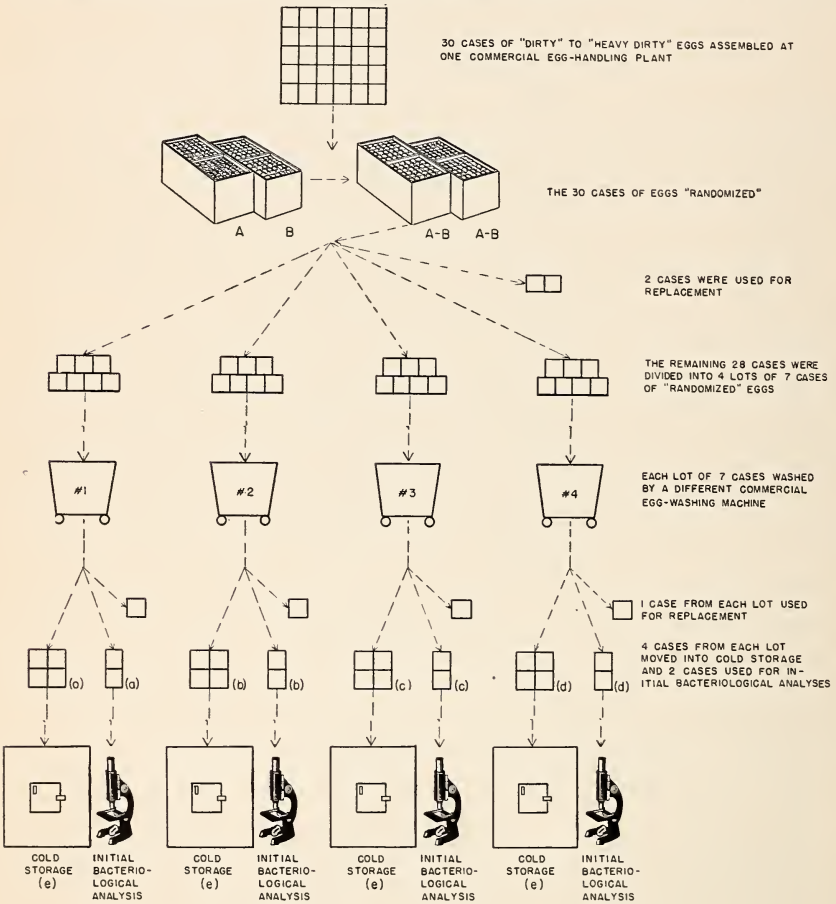
On 6 successive days an official egg grader graded the seven cases of eggs and filled cases with U. S. Grade B. or better quality. Four cases of these were selected and placed in commercial cold storage, two cases were used for breaking for initial bacteriological analyses, and the remaining eggs were set aside for replacement purposes. The method used in the study is illustrated in figure 4.

TABLE 4.—*Summary of cost data on washing eggs*

Item	Machine No.								Hand washing
	1	2	2-A	3	4	4–A	5	6	
Machines reported—number	8	2	2	5	4	1	3	1	1
Average cases washed per man-hour—number	7.5	4.3	7.0	5.0	4.5	5.0	9.6	2.5	0.9
Breakage—percent	Less than 1	Less than 1	Less than 1	Less than 1	Less than 1	Less than 1	Less than 1	5	4
Average original cost—dollars	1,008	853	464	428	455	1,818	630	240	
Repair—dollars	0 to 100	0	35 to 140	0 to 8	0 to 20	65	0 to 5	55	
Direct labor cost—cents	11.5	17.7	17.2	17.0	17.5	18.0	8.5	30.0	24.2
Indirect costs—cents	4.3	2.1	1.3	4.7	4.4	1.5	5.8	4.0	1.2
Total average cost per case—cents	15.8	19.8	18.5	21.7	21.9	19.5	14.3	34.0	25.4

Thus, 4 cases of eggs washed on each of the 4 machines were placed in storage on each of six successive days —a total of 96 cases of washed eggs for the six runs in the 4 machines. Forty-eight cases of these were stored as "natural" eggs whereas 48 cases were "oil-processed" by dipping the eggs in oil in accordance with commercial practice. In addition, 12 cases of dirty unwashed eggs were stored for control purposes. Of these one-half were stored as "natural" eggs and the other half as "oil-processed." In order to compare the results of the storage of washed and unwashed eggs with those of eggs normally found in storage, 12 cases of naturally clean graded eggs were also placed in storage.

All eggs going into storage and all eggs taken out of storage at periodic intervals were graded by the same official egg grader in order to mini-



(a) IDENTICAL EGGS
(b) IDENTICAL EGGS
(c) IDENTICAL EGGS
(d) IDENTICAL EGGS
(e) 2 CASES WERE STORED AS "NATURALS" AND 2 CASES AS "OIL-PROCESSED."

NOTE: FOR COMPARISON, 12 ADDITIONAL CASES OF NATURALLY CLEAN EGGS WERE STORED. IN ADDITION, 12 CASES OF DIRTY UNWASHED EGGS WERE STORED FOR CONTROL PURPOSES, ONE-HALF AS "NATURALS" AND ONE-HALF AS "OIL-PROCESSED."

FIGURE 4.—Procedure followed in selecting, randomizing, washing, and storing eggs in 1 commercial egg-handling plant. This procedure was repeated on six consecutive days.

mize differences in grading. The results of these gradings were converted to grade points, as described earlier, for comparison of general quality retention in storage.

After a storage period of 2 months, 16 cases of washed eggs from run No. 1, 16 cases of washed eggs from run No. 2, 4 cases of dirty unwashed eggs, and 4 cases of naturally clean eggs were removed from storage and graded. At the end of 4 months of storage the same number of cases from runs No. 3 and No. 4 were removed and graded, and after 6 months of storage the same number of cases for runs No. 5 and No. 6 were removed and graded.

At each storage interval the eggs were graded to determine the U. S. Grade and the loss from the previous grading was recorded. The edible eggs were then taken to the breaking room and broken out under commercial conditions. The opened eggs were judged as to edibility by appearance and odor. Any eggs of inedible quality were discarded, a record being made as to the number of such eggs in each lot.

Quality Change During Storage

The quality changes in the eggs during storage are shown in table 5. The data in this table include the average quality grade points after 2, 4, and 6 months of storage for the various lots of washed and unwashed eggs which were stored as "naturals" or as "oil-processed" eggs.

It will be observed that the values of the initial grade points were fairly close together, indicating that the method of randomizing gave uniformity with respect to initial quality. The naturally clean eggs had the highest number of quality points, and although all the soiled eggs were lower in quality points, the number of points was fairly uniform throughout. The greatest difference in initial quality was found in the eggs washed on the No. 3 machine.

The decline in quality grade points was higher in all lots of dirty and washed eggs than that found for the clean eggs, especially between the second and fourth months of storage.

The eggs that were stored as "oil-processed" showed less decline in quality than did the eggs stored as "naturals," with the exception of the soiled unwashed eggs, which showed a greater decline at the second and fourth months' gradings. The highest rate of decline during the 6 months of storage was found in eggs washed with machine No. 3. It is believed that the use of cold tap water with the machine was the cause of this decline in quality.

Table 6 shows the candling and broken-out losses in the various lots of eggs taken from storage after 2, 4, and 6 months. The candling losses were primarily due to black rots, mixed rots, stuck yolks, and mold spots, whereas the broken-out losses were generally due to a sour, musty, or fruity odor.

In general, the losses exhibited the same relationship as the quality decline shown in table 5. The greatest loss in both candled and broken-out eggs was found in eggs washed by the No. 3 machine. This was true in eggs stored as "oil-processed" as well as those stored as "naturals." The smallest losses during storage were in the clean, unwashed eggs. Quality changes and losses in storage are shown in figures 5 and 6.

Liquid-Egg Yield Upon Breaking

Upon the completion of the grading and removal of the loss in each storage lot, the eggs were broken and judged for edible quality by experienced commercial breakers. These breakers examined each egg

TABLE 5.—*Quality changes in eggs washed by different methods and placed in commercial storage for 2, 4, and 6 months, as determined by quality grade points*

Treatment	Trial or Case No. [1]	Quality grade points for initial and subsequent gradings and the percentage decline in quality grade points after each storage period							
		Eggs stored as "naturals"				Eggs stored as "oil-processed"			
		Initial (Avgs.)	Months of storage	After storage (Avgs.)	Decline	Initial (Avgs.)	Months of storage	After storage (Avgs.)	Declines
		Points	*Number*	*Points*	*Percent*	*Points*	*Number*	*Points*	*Percent*
Clean, unwashed	1 and 2	375.1	2	367.0	2.2	383.2	2	375.8	1.9
	3 and 4	381.6	4	369.0	3.3	383.6	4	373.3	2.7
	5 and 6	382.9	6	339.6	11.3	382.3	6	249.7	8.5
Soiled, unwashed	1 and 2	315.0	2	304.3	3.4	320.2	2	300.3	6.2
	3 and 4	340.0	4	312.7	8.0	305.0	4	257.8	15.5
	5 and 6	325.0	6	262.3	19.3	311.7	6	256.6	17.7
Machine No. 1	1 and 2	339.1	2	325.6	4.0	240.6	2	326.8	4.1
	3 and 4	332.5	4	285.1	14.3	331.7	4	295.8	10.8
	5 and 6	339.2	6	277.0	18.3	325.0	6	288.6	11.2
Machine No. 2	1 and 2	329.2	2	303.8	7.7	342.5	2	319.9	6.6
	3 and 4	332.5	4	280.2	15.7	317.5	4	281.8	11.2
	5 and 6	340.0	6	247.8	27.1	337.5	6	292.1	13.5
Machine No. 3	1 and 2	323.3	2	301.9	6.6	350.0	2	329.4	5.9
	3 and 4	301.7	4	249.8	17.2	322.5	4	282.1	12.5
	5 and 6	334.6	6	172.3	48.5	337.5	6	243.2	27.9
Machine No. 4	1 and 2	325.0	2	294.4	9.4	341.3	2	322.0	5.7
	3 and 4	314.2	4	267.6	14.8	322.5	4	290.4	10.0
	5 and 6	328.8	6	264.5	19.6	325.0	6	280.8	13.6

[1] The unwashed clean and soiled eggs are referred to by case numbers. All machine-washed eggs are referred to by the original trial numbers.

TABLE 6.—*Candling and breaking-out losses of eggs washed by different methods and placed in commercial storage for 2, 4, and 6 months*

Treatment	Trial or Case No. [1]	Months of storage	Percentage loss of eggs stored as "naturals," in²—			Percentage loss of eggs stored as "oil-processed," in²—		
			Candling	Breaking-out	Total	Candling	Breaking-out	Total
		Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Clean, unwashed	1 and 2	2	0.00	0.00	0.15	0.00	0.15	0.30
	3 and 4	4	.55	.85	1.40	.00	.40	.40
	5 and 6	6	1.05	.30	1.35	.95	.55	1.50
Soiled, unwashed	1 and 2	2	.55	1.95	2.50	.15	2.80	2.95
	3 and 4	4	.70	2.25	2.95	2.70	1.80	4.50
	5 and 6	6	2.05	1.80	3.85	1.95	.55	2.50
Machine No. 1	1 and 2	2	.05	.55	.60	.05	.30	.35
	3 and 4	4	2.40	1.30	3.70	1.35	2.85	4.20
	5 and 6	6	2.15	1.45	3.60	.75	2.50	3.25
Machine No. 2	1 and 2	2	.30	.95	1.25	.05	.95	1.00
	3 and 4	4	2.65	4.35	7.00	1.55	2.65	4.20
	5 and 6	6	4.65	3.70	8.35	1.35	.75	2.10
Machine No. 3	1 and 2	2	.35	1.05	1.40	.20	.70	.90
	3 and 4	4	9.50	17.15	26.65	2.70	11.70	14.40
	5 and 6	6	32.20	16.75	48.95	10.95	19.05	30.00
Machine No. 4	1 and 2	2	.40	.90	1.30	.35	7.50	1.10
	3 and 4	4	2.15	2.75	4.90	1.35	3.00	4.35
	5 and 6	6	3.35	2.20	5.55	1.35	.75	2.10

[1] The unwashed clean and soiled eggs are referred to by case numbers. All machine-washed eggs are referred to by the original trial numbers.
[2] Percentages are averages for each set of two trials or cases.

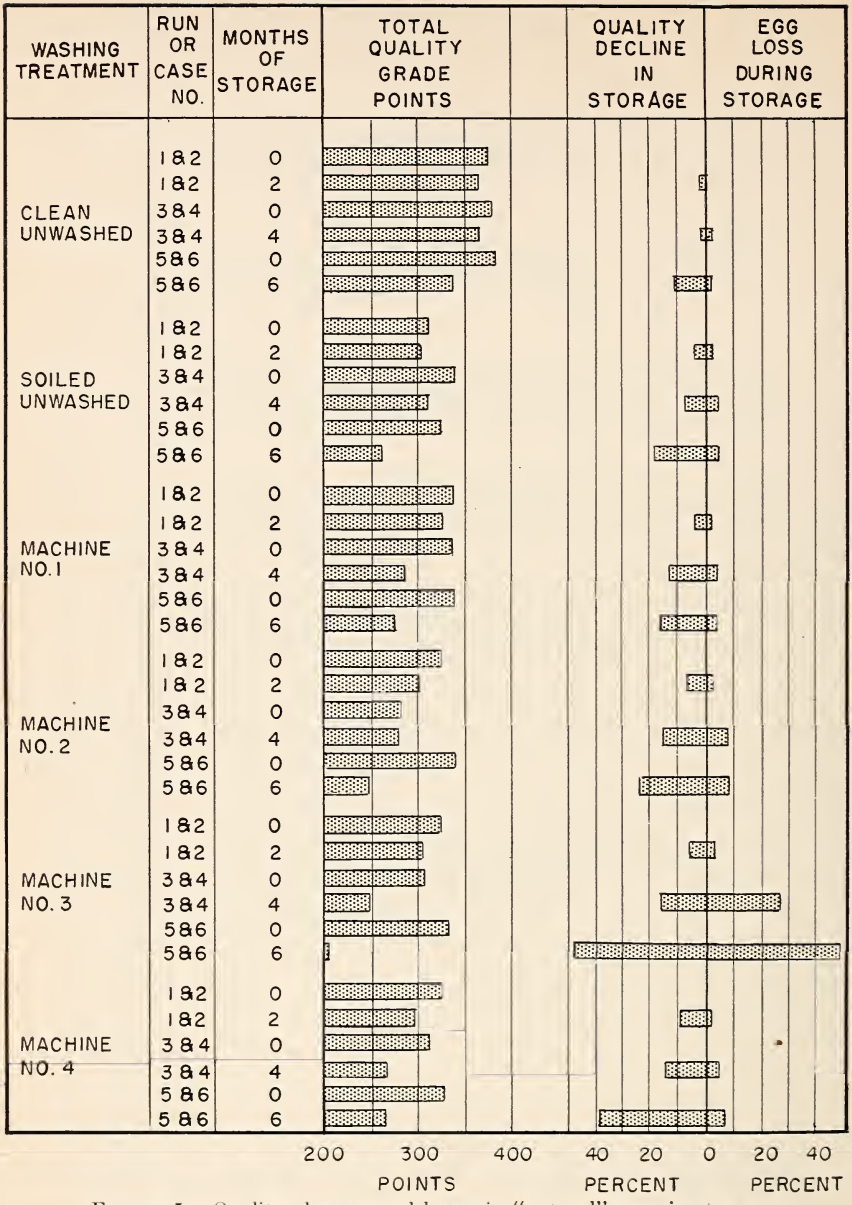


FIGURE 5.—Quality changes and losses in "natural" eggs in storage.

visually as it was dropped into the cup and each cup was checked for any off odor before it was dumped into the liquid-egg bucket. Only eggs judged to be edible were placed in these buckets. The buckets of liquid egg obtained from the test cases were weighed and a record kept of the number of pounds of liquid egg obtained. The data obtained are given in table 7.

It will be noted that in all cases there was a decline in yield as the period of storage increased. The clean unwashed eggs gave the highest yield throughout the period. The yield from the unwashed soiled eggs

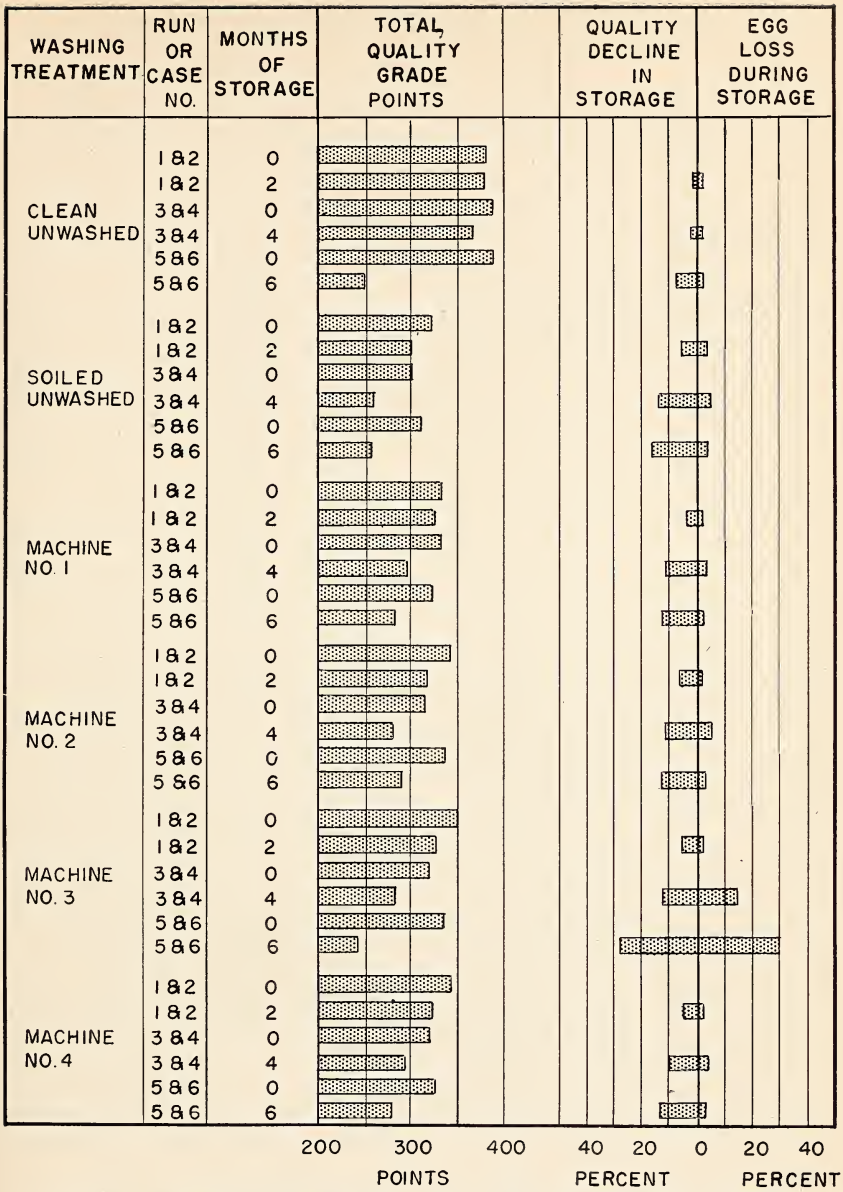


FIGURE 6.—Quality changes and losses in "oil-processed" eggs in storage.

was not as high as that from the machine-washed eggs, with the exception of those from machine No. 3. The liquid egg obtained from this lot was considerably less than from any other lot of eggs, and this low yield is attributed to marked contamination of the eggs caused by the use of cold tap water during the washing operation.

BACTERIOLOGICAL RESULTS

As each 15 dozen eggs from each case were broken, the edible liquid was thoroughly mixed and samples were taken for bacteriological analy-

TABLE 7.—*Yield of liquid egg from washed and unwashed eggs broken out after storage*

Treatment	Months of storage	Stored as "naturals"	Stored as "oil-processed"
		Average yield per case	Average yield per case
	Number	*Pounds*	*Pounds*
Washed:			
Machine No. 1	2	41.9	41.4
	4	39.4	
	6	38.5	38.6
Machine No. 2	2	40.9	41.3
	4	38.3	39.1
	6	36.2	38.4
Machine No. 3	2	41.3	41.6
	4	29.3	34.1
	6	20.5	27.3
Machine No. 4	2	41.3	41.5
	4	38.4	39.5
	6	37.8	39.0
Unwashed:			
Clean	2	42.0	42.8
	4	41.8	42.8
	6	40.3	40.2
Soiled	2	41.0	40.8
	4	38.5	37.8
	6	37.0	38.8

sis. All total viable bacterial counts were made in accordance with standard procedures of the American Public Health Association (*1*) by the use of tryptone glucose extract agar. Initially the coliform counts were made by using desoxycholate agar but in the 2-, 4-, and 6-month storage samplings violet red bile agar was used, as less difficulty was experienced in making the counts with this medium. The presumptive tests for *Escherichia coli* were made with 2-percent brilliant green lactose bile broth followed by the usual confirmatory test using eosin-methylene blue agar.

The initial samples were taken from machine-washed eggs only, as it was not possible to handle the additional samples from unwashed dirty and unwashed clean eggs with the personnel and time available.

In making the initial counts, 4 samples were taken from eggs washed on each of the machines during run No. 1, or a total of 16 samples for the run. This procedure was repeated on each of the other runs until all eggs had been washed and placed in storage.

As each lot of eggs was removed after a given storage period the eggs were candled, the loss removed, and the eggs broken by commercial breakers. Each 15 dozen eggs in each lot was sampled for bacteriological analysis.

The results of this study are given in tables 8 and 9.

The initial counts were quite varied, the variation ranging from a low of 7,000 to a high of 17,672,000 per gram. This supports the contention of Winter and Wrinkle (*17*) that the quality depends on clean eggs. There is an indication that in certain cases the eggs were passed as being of edible quality yet possessing a very high bacterial count. This probably means that the bacterial type causing the high count did not produce an odor that could be detected. The initial counts in runs 4, 5, and 6 were much lower than those of runs 1, 2, and 3.

In general, there was an increase in bacterial count with the lengthen-

ing of the storage period. The highest counts were found in eggs washed by machine No. 3.

Those eggs stored as "oil-processed" had lower counts than eggs stored as naturals. The reason for this is not apparent. It may be that the oil on the surface of the egg prevented the absorption of oxygen necessary to the growth of certain bacterial types.

In general, the coliform count decreased with length of storage. There is some evidence that there was a slight increase in these types of bacteria followed by a decline in numbers and not an increase throughout as was the case with the total count. There was no indication that coliform types of bacteria were responsible for deterioration and spoilage of eggs.

The *E. coli* content of the eggs was less than was expected in such dirty eggs. There was no indication that *E. coli* was a factor in the deterioration and spoilage of these eggs.

The following recommendations for the handling and washing of dirty eggs are based upon the results of this study:

1. Handle dirty eggs promptly. Dirty eggs are covered with material containing millions of bacteria—high temperatures, damp packing material, and long-time holding contribute to the contamination of the liquid on the inside of the egg.
2. Presoak dirty eggs for a short period by using either a strong water spray or submerging them in water containing a detergent to soften the soil and thus facilitate its removal. The temperature of the water should be considerably higher than the temperature of the egg to bring about an expansion of the egg contents during this process and so prevent polluted water from getting into the egg.
3. Transfer the eggs to the washing machine promptly and wash in water as warm as or warmer than that used to presoak the eggs. If cold water is used or the wet, dirty eggs are allowed to cool there will be a contraction of the egg contents and the drawing of contamination material inside the shell.
4. Cleanse the eggs with a mechanical washing unit that employs a scrubbing or brushing action to insure adequate removal of the soil from the surface of the egg. If a detergent or detergent-sanitizer is used it is essential that periodic checks of the concentration be made. The temperature of the water used in the cleansing should always be higher than that of the egg. An adequate supply of thermostatically controlled hot water is essential. In this study it was found that a supply of such water was lacking in most plants.
5. Sanitize the shells of the washed eggs with a germicidal rinse, dip, or spray of hot water containing a good sanitizing agent. The temperature of this water should be at least equal to that used in the washing operation. Follow the recommendations of the manufacturers of the sanitizing agent and make frequent checks to insure that it is being used in the proper concentration. After being sanitized, the eggs should be rinsed.
6. Allow cleansed eggs to become thoroughly dry, either in a hot air dryer or before an electric fan, before eggs are handled or cased.
7. Candle each egg and discard all eggs showing signs of being inedible or of doubtful value. It is impossible to candle dirty eggs adequately, and, therefore, it is essential that the eggs be candled after they are washed. Also, the percentage of inedible and low-quality eggs is likely to be higher in dirty eggs than in other types.

TABLE 8.—*Average total plate and coliform counts and E-coli tests of broken-out egg liquid from naturally clean, soiled, and washed soiled eggs stored as "naturals"*

[Total plate and coliform counts per gram of liquid egg]

Type of eggs and runs	Total plate count			Coliform count			*E-coli* [1]	
	Initial count	Length of storage	After storage	Initial count	Length of storage	After storage	Length of storage	After storage
	Number	*Months*	*Number*	*Number*	*Months*	*Number*	*Months*	
Naturally clean:	(1)			(1)				
1		2	8,000		2	0	2	Negative
2		2	1,000		2	0	2	Negative
3		4	160,000		4	0	4	Negative
4		4	4,000,000		4	0	4	Negative
5		6	1,600,000		6	0	6	Negative
6		6	850,000		6	0	6	Negative
Unwashed soiled:	(1)			(1)				
1		2	1,025,000		2	0	2	Negative
2		2	1,700,000		2	0	2	Negative
3		4	75,000		4	0	4	Negative
4		4	4,250,000		4	0	4	Negative
5		6	12,250,000		6	0	6	Negative
6		6	26,000,000		6	0	6	Negative
Machine No. 1:								
1	17,672,000	2	502,250	190,000	2	0	2	Negative
2	1,064,500	2	947,575	34,325	2	0	2	Negative
3	4,050,000	4	1,060,000	166,550	4	0	4	Negative
4	91,500	4	3,140,000	17,700	4	1,250	4	(2)
5	177,750	6	28,750,000	79,925	6	0	6	Negative
6	8,000	6	30,750,000	1,400	6	0	6	Negative
Machine No. 2:								
1	647,500	2	2,760,000	43,125	2	125	2	(3)
2	627,500	2	2,075,000	9,075	2	3,750	2	(3)
3	2,330,000	4	650,000	5,075	4	62,500	4	Negative
4	23,250	4	26,100,000	775	4	3,500	4	Negative
5	7,000	6	26,000,000	375	6	0	6	Negative

6	8,250	6	35,500,000	1,375	6	0	6	Negative
Machine No. 3:								
1	2,750,000	2	13,300,000	9,450	2	1,175	2	(3)
2	1,362,500	2	3,382,500	102,775	2	100	2	Negative
3	2,412,000	4	187,500	87,700	4	0	4	Negative
4	9,000	4	182,500,000	1,550	4	2,250	4	Negative
5	24,500	6	132,500,000	3,567	6	0	6	Negative
6	20,500	6	175,000,000	1,400	6	0	6	Negative
Machine No. 4:								
1	900,000	2	3,675,000	183,500	2	25	2	(2)
2	365,000	2	5,165,000	133,025	2	50	2	Negative
3	12,265,250	4	275,000	3,350	4	912,500	4	Negative
4	105,750	4	28,250,000	25,250	4	0	4	Negative
5	216,500	6	69,250,000	4,775	6	0	6	Negative
6	88,750	6	31,450,000	6,025	6	0	6	Negative

[1] No initial count taken.
[2] 1 out of 4 samples positive for *E-coli*.
[3] 2 out of 4 samples positive for *E-coli*.

TABLE 9.—*Average total plate and coliform counts and E-coli tests of broken-out egg liquid from naturally clean, soiled, and washed soiled eggs stored as "oil-processed"*

[Total plate and coliform counts per gram of liquid egg]

Type of eggs and runs	Total plate count			Coliform count			*E-coli* [1]	
	Initial count	Length of storage	After storage	Initial count	Length of storage	After storage	Length of storage	After storage
	Number	*Months*	*Number*	*Number*	*Months*	*Number*	*Months*	
Naturally clean:	(1)			(1)				
1		2	2,000		2	0	2	Negative
2		2	2,500		2	0	2	Negative
3		4	50,000		4	0	4	Negative
4		4	150,000		4	0	4	Negative
5		6	1,150,000		6	100	6	(2)
6		6	825,000		6	0	6	Negative
Unwashed soiled:	(1)			(1)				
1		2	340,000		2	11,000	2	(2)
2		2	6,825,000		2	0	2	Negative
3		4	100,000		4	0	4	Negative
4		4	3,000,000		4	0	4	Negative
5		6	3,500,000		6	0	6	Negative
6		6	8,000,000		6	0	6	Negative
Machine No. 1:								
1	17,672,000	2	1,112,500	190,000	2	15,000	2	(3)
2	1,064,500	2	508,500	34,325	2	0	2	Negative
3	4,050,000	4	1,200,000	166,550	4	1,500	4	Negative
4	91,500	4	1,125,000	17,700	4	750	4	Negative
5	177,750	6	2,875,000	79,925	6	4,000	6	(3)
6	8,000	6	8,375,000	1,400	6	0	6	Negative
Machine No. 2:								
1	647,500	2	138,000	43,125	2	75	2	(4)
2	627,500	2	3,192,500	9,075	2	2,500	2	Negative
3	2,330,000	4	475,000	5,075	4	100,000	4	Negative
4	23,250	4	8,550,000	775	4	0	4	Negative

5	7,000	6	36,000,000	375	6	2,750	6	[3]
6	8,250	6	8,000,000	1,375	6	12,500	6	[3]
Machine No. 3:								
1	2,750,000	2	4,000,000	9,450	2	825	2	Negative
2	1,362,500	2	816,500	102,775	2	3,500	2	Negative
3	2,412,000	4	2,075,000	87,700	4	1,107,500	4	Negative
4	9,000	4	48,000,000	1,550	4	0	4	Negative
5	24,500	6	51,250,000	3,567	6	0	6	Negative
6	20,500	6	86,250,000	1,400	6	0	6	Negative
Machine No. 4:								
1	900,000	2	727,500	183,500	2	3,425	2	[4]
2	365,000	2	640,200	133,025	2	75	2	Negative
3	12,265,250	4	4,170,000	3,350	4	603,750	4	[4]
4	105,750	4	5,750,000	25,250	4	0	4	Negative
5	216,500	6	43,400,000	4,775	6	0	6	Negative
6	88,750	6	5,075,000	6,025	6	0	6	Negative

[1] No initial count taken.
[2] 1 out of 2 samples positive for *E-coli*.
[3] 1 out of 4 samples positive for *E-coli*.
[4] 2 out of 4 samples positive for *E-coli*.

8. Market washed eggs promptly, using new, dry packing material, and with strict attention to temperature and conditions of handling, or break them promptly for the production of frozen or dried eggs. The egg breaking should be done by experienced workers and particular attention should be given to eggs with slight off-odors and slightly cloudy appearances, as such eggs are likely to have very high bacterial counts.

Do not store washed dirty eggs. In general, they are poor storage risks, even when washed and sanitized under optimum conditions. Their greatest value lies in their immediate use.

LITERATURE CITED

(1) American Public Health Association.
1948. standard methods for the examination of dairy products. 9th ed.

(2) Bryant, R. L., and Sharp, P. F.
1934. effect of washing on the keeping quality of hens' eggs. Jour. Agr. Research 48: 67-89.

(3) Bushnell, L. D., and Maurer, Otto.
1914. some factors influencing the bacteriological content and keeping quality of eggs. Kans. Agr. Expt. Sta. Bul. 20. 29 pp.

(4) Diehl, H. C.
1948. washed shell eggs and their storage. Amer. Egg and Poultry Rev. 9 (13) 10.

(5) Funk, E. M.
1948. experiments in cleaning soiled eggs for storage. Mo. Agr. Expt. Sta. Bul. 426. 33 pp., illus.

(6) Gunderson, Millard F., and Gunderson, Shaun D.
1945. spot plates for sanitation. U. S. Egg and Poultry Mag. 51 (1) 21.

(7) Haines, R. B., and Moran, T.
1940. porosity of, and bacterial invasion through the shell of the hen's egg. Jour. Hygiene 40 (4) 453.

(8) Jenkins, M. K., and Pennington, M. E.
1919. commercial preservation of eggs in cold storage. U. S. Dept. Agr. Bul. No. 775.

(9) ———, Hepburn, J. S., Swan, C., and Sherwood, C. M.
1920. effects of cold storage on shell eggs. Ice and Refrigeration. 58 (3) 140, illus.

(10) Lorenz, F. W.
1950. egg washing field trials. Newlaid News. 27 (10) 9.

(11) ———, and Starr, Phoebe Betty.
1952. spoilage of washed eggs. I. effect of sprayed versus static water under different washing temperatures. Poultry Sci. 31 (2) 204.

(12) Michigan State College.
1949. changes in egg quality during marketing. Mich. Agr. Expt. Sta. Special Bul. 361. 39 pp., illus.

(13) Miller, M. Wayne.
1948. should eggs be washed. Washcoegg. 26 (7) 7, illus.

(14) Rettger, L. F.
1913. the bacteriology of the hen's egg with special reference to its freedom from microbic invasion. Storrs (Conn.) Agr. Expt. Sta. Bul. 75.

(15) Stuart, L. S., and McNally, E. H.
1943. bacteriological studies on the egg shell. the role the shell plays in preventing infection of the albumen and yolk. U. S. Egg and Poultry Mag. 49 (1) 28, illus.

(16) Thompson, L. N.
1948. the egg washing problem. Newlaid News. 26 (7) 3.

(17) Winter, A. R., and Wrinkle, C.
1949. frozen egg quality depends on clean eggs, clean equipment, quick cooling. U. S. Egg and Poultry Mag. 55 (1) 7.

(18) Wolk, J., McNally, E. H., and Spicknall, N. H.
1950. the effect of temperature on the bacterial infection of shell eggs. Food Tech. 4 (8) 316.

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